REPORT TO THE CHAIRMAN OF THE RESEARCH AND DATA COMMITTEE OF THE AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.

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RESEARCH IN AGRICULTURAL ENGINEERING.

This report summarizes the more important features of work in agricultural engineering research which has been completed or in progress during the past year, more especially at the State colleges and agricultural experiment stations and incidentally at some other public and private institutions in this country and abroad, and formulates some general recommendations as to procedure in future research work in the subject.

A great deal of work related to agricultural engineering has been in progress, but a review of projects and of data already submitted indicates an apparent lack of the research spirit in a great number of cases. This is probably largely due to circumstances. A striking feature of the work is the fact that a large part of it has apparently been conducted either by or in cooperation with some other agricultural division to meet immediate needs in the solution of a specific problem. This, together with the demands for popular information, has resulted frequently in the mere application of old well-established engineering principles to some perhaps new agricultural problem, or in more or less emergency testing work of little permanent value, to meet the immediate requirements of the specific problems in hand. Thus the advancement of the engineering itself has often not been given the consideration it merits.

In short, there has not been nearly as much effort to increase the basic knowledge of agricultural engineering in this country as has been the case with other branches of pure agriculture. There are, however, some well marked exceptions not only in this country but abroad.

Research work in subjects classed as agricultural engineering has included the following:

Materials	Farm Buildings and Fences or Farm Structures
Farm Machinery	Roads and Bridges
Irrigation	Water Supply, Sewage Disposal and Sanitation
Drainage	Miscellaneous.

MATERIALS.

The work on materials has consisted mainly of pure research. The work on alkali-proofing of cement and concrete and the preparation of alkali-proof cements at the Wyoming Experiment Station has proceeded to the point at which some definite basic principles are being laid down. The work on roofing materials at the Iowa station appears to have been mainly a comparison of different types of materials. While this does not appear to be research as far as the

materials are concerned, it can in a way be classed as research, if the ultimate intention is to establish definite rules for the use of certain roofing materials for certain definite conditions.

Considerable work has been done on timber preservation at the Iowa California, Pennsylvania, Minnesota, North Carolina and several other State stations. It is difficult to determine the exact status of this work although some of it is undoubtedly research in that its ultimate purpose is the establishment of methods and basic principles of procedure for the State conditions. Recent reports from the North Carolina station especially indicate this. The studies of paints and painting methods at the North Dakota station are also noteworthy.

Considerable work on materials which is of interest to agricultural engineers has been in progress at institutions not of an agricultural nature, such as the U. S. Bureau of Standards, the Lewis Institute of Chicago and the U. S. Bureau of Mines. There is apparently hardly a building material which has escaped the scrutiny of the Bureau of Standards. The cooperative project on concrete drain tile has yielded some noteworthy basic information. We are also indebted to the Bureau of Standards for considerable basic information on metals, particularly steels, semi-steels, cast-iron, brass and bronze, which are used in the manufacture of farm machinery. Data on woods for this purpose are also available and a report was recently issued on the treatment of harness leathers. The work on cements and concrete at the Lewis Institute needs no comment other than to say that the basic principles established not only in the past year but also in previous years at that institution on the proportioning, mixing and placing of concrete are striking examples of the results of true research. It is to be noted that a number of our engineering schools have also conducted some similar work which is of interest to agricultural engineers.

Owing to the agencies at present engaged in research on materials, it would seem that there is little more than can be taken up to advantage by the State experiment stations in connection with structural building materials. However, there is an open field for more research work on metals and woods used in the construction of farm machinery.

FARM MACHINERY.

The subject of farm machinery as considered here is very broad and includes not only cultivating and harvesting machines but motors, motor fuels, and power and power-driven appliances in general. It is perhaps the biggest branch of agricultural engineering, has probably seen the most costly experimenting, and, from the standpoint of actual research, seems to have been the most neglected.

Many reports of so-called experimental work with farm machinery are available and much of such work is in progress at the State colleges and experiment stations, but frequently such work is conducted entirely by or under the supervision of agronomists. The work in the long run usually resolves itself into simple comparative tests of different types and makes of machines and leaves us in the position of using the best of merely what is available.

Aside from the work done by Dr. White, that by Fischer in Germany and perhaps a few others, there has been very little research conducted on plows since Thomas Jefferson figured out a curve for a moldboard plow, although there has

been a lot of costly experimenting. Perhaps such work is not needed but if so, then why all the different types and makes of moldboard plow on the market? We know in a general way what plow to use for a certain type of soil but there are many plowing conditions under which no plow gives entire satisfaction. There are certain rules of thumb about plow adjustments for suction, side draft, etc. but what is the basis for these rules other than fit and try. For instance, the recent tractor trials at Lincoln, England, brought out the fact that plow designers have not as yet put out implements which take into account all of the requirements of mechanical traction. We ought to know more about plows, that is, something definite and basic. Undoubtedly plow manufacturers would welcome basic information on plows which would save them costly experiments. The plowing tests at the Iowa station are indicating our lack of basic knowledge most strikingly.

Numerous tests of tillage and tillage machinery have been in progress during the past year but in the majority of cases under the supervision of the agronomy departments, thus making the machinery of secondary importance and merely a means to an end. Such tests have been in progress at the Kansas, North Dakota, Oregon, Ohio, South Carolina, South Dakota and California stations in particular. The Deutsche Landwirtschafts Gesellschaft has also been active in this respect. On the other hand, a step in the right direction are the studies of the draft of farm implements at the Iowa, Montana and Missouri stations, and of the power required for plowing at the California station. Such studies if carried far enough should begin to indicate facts of considerable basic importance in design and manufacture.

There is perhaps more known in general and less in particular about tractors than any other farm machine. A recent specification sheet listed some 314 tractors of some 220 different makes on sale in the United States alone. They can not all be right and it is believed that no one knows whether any one tractor or type of tractor is the optimum of efficiency. The need for research work on tractors to provide some definite and well-established working principles to be used in design and manufacture is reflected, both in the large number of different makes for sale and in the tractor inspection laws which have come into effect in certain States, notably Nebraska. This need was also brought out strikingly at the recent competitive trials of tractors at Lincoln, England, under the auspices of the Royal Agricultural Society of England in cooperation with the Society of Motor Manufacturers and Traders. The official report of the trials expressed doubt as to the desirability of the competitive element in technical trials of tractors until design and construction have reached some definite standard. It is to be noted that machines of American manufacture were active in this competition. Undoubtedly many tractor manufacturers have conducted considerable research as is evidenced by their success. But it is believed that many others have learned only by very expensive experiment and are still in the dark in that they have learned mainly what not to do and very little of what to do.

Most of the work on tractors at the State colleges and experiment stations has consisted either of comparative or competitive tests of different makes or of economic studies. Research into the economics of tractors is undoubtedly of great importance. Its weak point at present is that it must be based on experience with the tractors available and not always on tractors designed and constructed on the basis of firmly established basic facts. It is conceivable that two neighboring farmers may obtain satisfactory results from one design of tractor and unsatisfactory results from another design of the same rating, thus making their econom

ic reports contradictory. Consequently, the results of economic studies of tractors may frequently be of questionable value. In spite of this, considerable helpful data have been secured by the Iowa, Pennsylvania, Kentucky, Florida, South Dakota, Nebraska and several other stations on the economic use of tractors, most of which will serve as a basis for future research in design and construction.

Special engineering studies of tractors have been in progress at the Iowa, Montana, Indiana, California and Nebraska stations. It is believed that the work at these stations more nearly approaches research than that at any other station. The Iowa station has taken up motor cultivation and such matters as traction equipment. It is to be noted in this connection that the Institute National Agronomique of France has entered into a somewhat extensive research on tractors, which is apparently intended primarily to aid manufacturers in the production of tractors satisfactory to farmers. The Society for the Encouragement of National Industry in France is also interested in and is assisting in this work. France has realized the lack of basic knowledge of tractors and has indicated an apparent intention to place future manufacture of these and also other farm machines on a sound research basis.

About the same general principle applies to work on other types of farm machinery at the colleges and stations. With a few exceptions, most of the work has consisted merely of demonstrations of old principles. A few notable exceptions are the plow draft tests at the Iowa station and the milking machine investigations at the Illinois, Iowa, South Dakota, New York and California stations. Studies of labor-saving machines and fertilizer distributors are also in progress at the Iowa station and of horsepower at the Oregon station.

Attention may well be drawn to an example of methods of research in agricultural machinery employed by the National University of Buenos Aires in Argentina. The work is started by conducting power distribution tests of an agricultural machine. For instance, tests of a series of grain binders showed that 16.5 per cent of the driving power was utilized by the sickle, 7.1 per cent by the reel, and 42.2 per cent by the canvas elevator. Tests of materials are conducted simultaneously, the purpose being to establish basic principles for the materials, design, and construction of a binder giving the highest all-around efficiency for the conditions imposed. Reports have been received describing similar work on threshers and corn shellers. In short, it is the desire of that institution to know something about how these machines should be built rather than to limit their work to obtaining a knowledge of the comparative values of available types.

Farm motors, including tractor engines, need considerable development, especially in view of the motor fuel situation. The U. S. Bureau of Standards has recently been engaged in considerable research on internal-combustion engines, with particular reference to carburation and ignition and has established a number of fundamental principles relative to points which have heretofore been the subject of much argument. Such work is also in progress at the Kansas and Indiana Engineering Experiment Stations. The work of the Florida Experiment Station and the U. S. Bureau of Mines on fuels for internal-combustion engines is also noteworthy. The U. S. Department of Agriculture is engaged in research on the production of straw gas for internal-combustion engines. It should be noted that the British Ministry of Agriculture is preparing to establish research on all farm machines.

IRRIGATION

Considerable research on irrigation has been in progress at the State stations during the past year. This subject has had the advantage of years of study and has apparently had ample support. The research spirit has prevailed in irrigation resulting in the putting forth of considerable basic information. The Irrigation Investigations Division of the U. S. Department of Agriculture has as usual been quite active, although apparently somewhat limited as to appropriations. Irrigation investigations have also been conducted during the past year at the California, Nevada, Utah, New Mexico, Colorado, Oregon, Montana, Arizona, Nebraska, Oklahoma and Idaho stations. California has perhaps been the leader in amount and scope of such research. Special studies have been conducted on methods of irrigating certain crops, such as alfalfa, rice, vegetables, vineyards, orchards and small fruits, special attention being paid to soil moisture and duty of water. Duty of water and soil moisture studies have also been in progress at the Oregon, New Mexico, Idaho, Nebraska and Utah stations. The Colorado station has continued its work on the measurement of irrigation water, particular attention being paid to current meters and the Venturi flume. The Montana station has also conducted work of this nature. Evaporation and groundwater movement experiments were conducted at the Colorado, New Mexico, Utah, Oklahoma and Arizona stations. Studies of alkali and the reclamation of soils made alkaline through the excessive use of irrigation water were conducted at the New Mexico, Utah, California and Arizona stations. Seepage studies were conducted at the Montana station. Irrigation pumping plant investigations were under way at the California, Nebraska, Utah and Arizona stations, and in this connection the California station conducted work on the manufacture and use of concrete pipe for distribution of pumped irrigation water. The Oregon station has undertaken studies of the feasibility of irrigation with a view to improving the distribution and use of irrigation water and the State irrigation water laws. The Irrigation Investigations Division has, in addition to other activities, issued three important reports, one on spillways for reservoirs, one on the capillary movement of soil moisture and one on the flow of water through concrete pipe. The two last reports are especially typical of true research. In addition, that Division has engaged in research on current meters which has resulted in the design of a new and efficient meter.

DRAINAGE.

The research work in drainage, while perhaps not so extensive as that in irrigation, has been none the less typical of true research. Most of the State stations have conducted research of one kind or another in drainage and some special reports have been issued by the Drainage Investigations Division of the U. S. Department of Agriculture. Two of these, one on the flow of water in drain tile, and the other on the flow of water in dredged drainage ditches, are especially typical of true research. It is to be noted that the French National Academy of Sciences has also reported similar studies on the flow of water. The work of the Iowa Engineering Experiment Station on drainage and drainage structures is also particularly noteworthy as being typical of true research in drainage.

Drainage studies were in progress during the past year at the California, Colorado, Oregon, Indiana, Arizona, Ohio, Missouri, Iowa, Minnesota, Montana, New Mexico and Alabama agricultural experiment stations. The extent of this work

in irrigated areas indicates the growing interest in drainage of irrigated lands. The work in Alabama consisted mainly of the usual swamp and overflow land reclamation which, while not research as a whole, usually entails considerable incidental research. The work at the Indiana station on the effect of drainage and soil moisture on soil acidity, at the Ohio station on the loss of plant food in drainage water, at the Missouri station on water penetration, evaporation, and run-off, and at the Minnesota station on the movement of soil water are typical of true research in drainage in the more humid sections. The work at the California, Arizona, New Mexico and Oregon stations on the drainage and improvement of wet and alkaline soils are typical examples of research on the drainage of irrigated lands. The Colorado station has entered the drainage field with a project on the drainage requirements of crops and drainage factors for Colorado conditions. This shows a decided step forward in the control of soil moisture in semiarid regions.

FARM STRUCTURES.

The subject of farm buildings and fences, or more generally speaking farm structures, received considerable attention at the State colleges and stations during the past year. While considerable of this work was mere demonstration, there was a large amount of work which may be classed as research. Almost every State did some work on silos, but research on silos was limited to the Iowa, North Carolina, Michigan, Missouri, Guam and perhaps a few other stations where studies were conducted of silo wall treatment, silo capacities and general design, based on local conditions.

Research on poultry housesreceived the usual attention. The New Jersey, Kentucky, California, Utah, Indiana, Maryland, Washington and Idaho stations continued work on their comprehensive poultry house projects taking up such special questions as artificial lighting in its relation to egg production and improvement in design for local conditions.

Studies of the design of self-feeders for hogs were conducted at the New Jersey, Ohio, Pennsylvania and Arkansas stations. It may stretch the imagination to class such work as research, yet it is evident that these stations had in mind the laying down of basic principles to aid the animal husbandry departments in their work of hog fattening. Closely related to this work was the work at the California station on the design and construction of feed lots. The Nebraska, California and Iowa stations continued their studies of hog-house design. The Iowa station also conducted general studies on equipment for live-stock feeding and management and on farm structures in general. A feature of the Iowa work is the study of the efficiency of barn ventilating systems. The Indiana station has also had a rather comprehensive project in operation studying the representative types of farm buildings in the State in an effort to lay down basic principles for the State conditions. The California station was engaged in studies of the design of beef and dairy barns and also of houses or hutches suitable for use in raising rabbits. The Oregon and California stations engaged in studies of equipment and structures for the handling, storage and preservation of manure. The work of the French Institute National Agronomique on farm structures is also noteworthy, especially that recently in progress on structures to meet the emergency conditions in the devastated regions. The analytical methods employed by the French engineers may well be given consideration.

ROADS AND BRIDGES.

Practically no research work was done on roads and bridges by the State agricultural experiment stations, as this work is for the most part handled by the highway commissions of the different States and by the U. S. Bureau of Public Roads. No information was secured regarding research by these institutions on the subject other than that contained in their publications. Further mention will not be made of this branch of the subject except to include the more important publications in the data references, and to note that the Chief of the Bureau of Public Roads recently indicated the growing need for research in highway problems.

WATER SUPPLY, SEWAGE DISPOSAL AND SANITATION.

The subject of water supply, sewage disposal and sanitation has received very little research treatment. This is one of the subjects in which it is believed we have offended the most by attempting to teach without basic knowledge. Only a few public institutions seem to have recognized that fact. There is abundant literature on the subject with new additions coming in every day, yet practically none of it contains anything new. An instance occurred recently in which a State board of health recommended procedures in water purification which had been described by the Federal Government some eight years before, and subsequently through necessity materially modified.

A number of our public institutions in response to popular demand are continually putting out literature descriptive of methods and apparatus for the disposal of sewage, the purification of water and other sanitary processes, frequently without any apparent substantial basis other than perhaps inadequate experiment. The excuse for this is that the information is the best available and the need is great. This is a strong argument for research in the subject.

The U. S. Public Health Service has sounded a warning in this connection, and has condemned a number of the practices which have been recommended by other institutions without a knowledge of basic facts. That Service has had a project on residential water supply and sewage disposal in operation for some years, and only recently has it begun to lay down basic principles.

The Missouri, Montana, Michigan, and Idaho stations, the New York State College of Agriculture, the Iowa, Kansas, Indiana, Oregon and Washington engineering experiment stations, and a few of the State boards of health, especially those of Minnesota and Ohio, have apparently been taking steps along the same line. The Wisconsin station seems to have continued its comprehensive project on the disposal of creamery sewage and the Michigan station has taken up a study of dairy sanitation. The New Jersey station has initiated a project on the biology of sewage filters.

The need for research on this subject is reflected in the attitude of some of the foreign agricultural institutions, especially those in Holland, Germany, France, and in some of the tropical protectorates. A project of this nature was recently begun in the Dutch East Indies by a comprehensive study of the gases found in septic tanks and the relation of gas formation to the design of systems which purify sewage, the purpose being purely and simply to establish basic principles. It is evident that while plenty of mechanical principles are available for use in rural sanitary engineering, there is a need for research to establish basic working

relations between sanitary and mechanical principles to meet specific classes of conditions.

MISCELLANEOUS.

Considerable research of a miscellaneous nature has been under way. The Idaho, Oregon, Minnesota and Wisconsin stations and perhaps a few others are engaged in conducting comprehensive land clearing investigations, and the Idaho station is investigating the utilization of logged-off lands. In this connection a very neat piece of pure research was conducted and recently completed by a private explosive manufacturing company at the suggestion of the States Relations Service of the U. S. Department of Agriculture, on the removal and utilization of pine stumps from logged-off lands in one of the southern States. Of course, this company was primarily interested in the use of explosives for the removal of stumps but the researches showed that the stumps after removal could be distilled and made to yield products of sufficient value to pay for the removal, distillation equipment and all expenses, and yield a net revenue on the whole project, in addition to leaving the land cleared ready for cultivation. The basic principles of this process were established and preserved and are now available for practical use. The Ohio and Arizona stations conducted work on the use of dynamite in the preparation of soil for crops and the Wisconsin station on the use of dynamite in tree planting and T.N.T. for general blasting.

The South Dakota station continued its work on ice-making on the farm, the Kansas station its milling investigations project and the Iowa station the study of soil erosion and preventive measures therefor.

CONCLUSION ON RESEARCH.

This review shows that in spite of circumstances tending to discourage research, there has been some pure research in agricultural engineering at the State agricultural experiment stations and other institutions during the past year. It is known that many of the State stations have not only been seriously handicapped through lack of funds for research work, but also through lack of suitable personnel. Many of the more capable research engineers have given up research work to take better paid positions in other lines. Such a situation is a serious one from the standpoint of the permanency of agricultural engineering accomplishment.

Every phase of agricultural engineering should be based upon the results of careful research to give both satisfactory and permanent results. It is not within the province of this report to outline methods of procedure in individual research projects, but it seems advisable to call attention to some of the important points brought out in a recent editorial appearing in the Experiment Station Record (Vol. 43, No. 4) on research projects in agriculture. It is pointed out that a project in agricultural inquiry is first of all a constructive scientific undertaking which aims to advance science and through it the art. Its purpose is "to find out and learn how", and thus to understand the purport of results obtained. It deals with things that are fundamental, aiming to disclose the underlying principles or conditions of relationship and seeking to develop basic facts and establish their universality. Originality in research implies going outside of what is known or practiced and injecting something new in purpose or procedure. The scientific method of advancing knowledge is the substitution of detailed and verifiable results for broad, unproved generalities de-

rived from practice or from inadequate experiment and speculation. A research project should have a definite aim and should be progressive in its conception and its conduct, proceeding in a systematic and orderly way from one essential point to another. Owing to its nature it is necessarily restricted in scope. It always looks toward completion and should be planned with this in view. It is recommended that wherever possible, future work in agricultural engineering be planned with these points in view.

AGRICULTURAL ENGINEERING DATA.

It has apparently been the desire of the Society to combine the subjects of research and data into one committee. While they are two separate and distinct subjects, yet they are closely related and dependent upon each other. Research yields basic working data and general data is indispensable in research. This Society has long been talking about a data book. One of the main aspects of research is to determine the purport of data at hand. There is a large amount of data available of one kind and another related to agricultural engineering. Therefore the intelligent preparation of an agricultural engineering handbook will undoubtedly entail some very patient research.

There is appended a list of selected references to agricultural engineering data obtained in the course of conducting the rural engineering section of the Experiment Station Record. These references have been selected on the basis of their research value and should be added to the list of references submitted in the report of the data committee last year. If last year's references have been preserved, as they undoubtedly have, the files of the Society should now contain data references dating from about 1912 up to date. This list just about covers the important agricultural engineering research work of the world for that period.

As pointed out in last year's data committee report, the work of preparing a handbook is not only large but endless. Since the Society now has a monthly journal for its proceedings, it is recommended that the research and data committee for the coming year be authorized to submit monthly to the editor of Agricultural Engineering sufficient data in complete working form to fill at least one page, and that the editor be authorized to arrange and print such data in each issue of the Journal in such form that it can be conveniently cut out by each member and inserted in a loose-leaf binder. In this connection it is recommended that the editor be referred to the suggestions of the 1918 data committee as to size and shape of data sheets, and that he be authorized to modify such size and shape to conform to the requirements of the Journal, but consistently with good practice as regards pocket loose-leaf data books.